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Donald R. Buist
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Fuel Economy Office
Environmental and Safety
Engineering Staff

Ford Motor Company
The American Road
Dearborn, Michigan 48121

October 3, 1991

Air Docket (LE-131)
U.S. Environmental Protection Agency
Room M-1500
401 M Street, S.W.
Washington, DC 20460

Attention: Public Docket No. A-91-46

The information provided with this communication reflects Ford Motor Company's (Ford) comments on the September 3, 1991 Federal Register Notice regarding the July 12, 1991 Ethyl Corporation (Ethyl) submittal of an application for a waiver of the prohibition of certain fuels and fuel additives set forth in Section 211(f) of the Clean Air Act. The application seeks a waiver for the gasoline additive MMT, commercially labeled by Ethyl as HiTEC 3000, to be blended at a level of 1/32 grams per gallon manganese (Mn).

In addition to the information provided herein, Ford has also supplied to the Docket testimony and test data from the September 12, 1991 EPA Hearing (Hearing). This testimony and data, while titled as that of MVMA, should also be considered part of the Ford statement, as it contains Ford data and conclusions which have the concurrence of other member MVMA companies.

We have completed testing the eighth and final vehicle at the 100,000-mile point (Escort #318). A description of the Ford test program was submitted to the EPA Docket on September 4, 1991 and discussed at the Hearing. Updated plots of the hydrocarbon (HC), carbon monoxide (CO) and oxides of nitrogen (NO_x) deterioration through 100,000 miles for all eight vehicles are enclosed. A listing of the emission test data from the eight vehicles was supplied to EPA with our letter dated September 23, 1991.

With the inclusion of test data from this eighth vehicle, our Ford test fleet on average demonstrates a 200 to 300-percent increase in HC emissions for the vehicles which accumulated 100,000 miles with MMT, as compared to non-MMT fueled vehicles. Another way to compare the HC test results is that the MMT-fueled vehicles' average deterioration factor is approximately twice that for non-MMT fueled vehicles. An inspection of the catalysts from the vehicles fueled with MMT indicates a thick layer of Mn_3O_4 covering the washcoat and some cell blockage. These findings corroborate those from Canadian vehicles we have inspected (reference Ford's July 23 and October 29, 1990 communications to Docket No. A-90-16).

We have also included as an enclosure test data from emission control device testing. A discussion of these results is contained under the section entitled "Emission Control Device Functional Analysis and Visual Inspection Test Results." This test program consisted of testing EGO sensors and catalysts from MMT-fueled vehicles on non-MMT test vehicles, and vice versa, to determine the extent to which the function of these devices was impaired. The results from this test program indicate an average 66 percent increase in HC levels on the clear-fueled Escort vehicle when equipped with EGO sensor and catalyst from the MMT-fueled vehicle. Additional testing on Explorer vehicles and the other two Escort vehicles needs to be completed and will be supplied to EPA when available.

We have answered the questions raised by Ethyl during the Hearing concerning the Ford eight-vehicle test program (enclosed). In addition, the shortcomings of the Ethyl 48-vehicle test protocol have been outlined in both MVMA testimony at the Hearing and in Ford's October 29, 1990 communication to the Air Docket. We believe our test data clearly indicates that MMT causes the failure of emission control devices to meet applicable standards and it impairs to a significant degree the performance of emission control devices. As such, the only recourse available to EPA is to deny Ethyl's waiver request.

Sincerely,

D. R. Buist

Enclosures

ENCLOSURES TO FORD MOTOR COMPANY'S OCTOBER 3, 1991 COMMENTS ON ETHYL CORPORATION'S WAIVER REQUEST TO ADD MMT TO GASOLINE

TABLE OF CONTENTS

FORD MOTOR COMPANY'S ANSWERS TO ISSUES RAISED BY ETHYL CORPORATION DURING THE SEPTEMBER 12, 1991 EPA HEARING ON MMT

ETHYL: Ford data and test vehicles are too limited.

FORD: We believe it is the quality of our data and not the quantity that matters. We indicated through the MVMA statement at the September 12, 1991 EPA Hearing (Hearing) in Washington, DC the numerous flaws with the Ethyl test program which more than offset their additional test vehicles and data points. The eight vehicles tested by Ford are not the only data which refute the results of the Ethyl test program. The Canadian data we outlined in our July 23, 1990 communication and the catalyst efficiency data described later in this communication all corroborate the tailpipe emission findings of the eight vehicles. In addition, there is the Ford component test data attached to this communication which demonstrate impaired function after mileage accumulation with MMT.

ETHYL: Ford did not test vehicles every 5,000 miles.

FORD: EPA no longer requires manufacturers to test certification durability vehicles every 5,000 miles. There is nothing statistically significant about testing vehicles every 5,000 miles. Running additional tests at longer intervals provide a solid data set. Ford elected to use longer intervals with six tests at each interval in order to expedite the data generation process while assuring statistically significant results.

ETHYL: Car-to-car variations in emission data are high (at 55,000 miles one clear Explorer had HC levels of 0.15 gm/mi, and the other was 0.35 gm/mi).

FORD: The HC test results for the Explorers do not have as large a spread as vehicles identified by a "B" in the Ethyl test program. The average HC levels for the six "B" vehicles at 50,000 miles with clear fuel are as follows: 0.38, 0.54, 0.49, 0.14, 0.16 and 0.20 gm/mi. Clearly, there is a greater spread in these data than the Explorer's. From the vast experience we have in emission testing vehicles, a difference in HC levels by a factor of two between two like vehicles after 50,000 miles is not uncommon.

ETHYL: The mileage accumulation route used by Ford may be too stringent.

FORD: We believe the automobile industry is in the best position to design a representative mileage accumulation route. As indicated in MVMA's Hearing testimony, "...driving schedule representative of actual customer usage...", is the position of industry as it relates to the Ford route. Additionally, Ethyl used some mileage accumulation routes which had speeds higher than those used by Ford. For example, a pair of Corvettes accumulated 25,000 miles at 100 mph. A pair of Crown Victorias accumulated 25,000 miles with 45 percent of the mileage at 65 mph and an additional 10,000 miles with 45 percent of the mileage at 80 mph. At no time did Ethyl indicate that these higher speeds are too stringent.

ETHYL'S LACK OF INCLUSION OF TRUCKS IN ITS TEST PROGRAM

Ethyl should have included trucks in its test program because of their significantly higher operating temperatures and loads than those of passenger cars. Additionally, trucks represent a significant portion of the market. For the first time in Ford Division's history, trucks are projected to outsell cars during some portions of 1991.

It has been seen from the Ford test data the Explorer trucks demonstrated a much greater deterioration in HC emissions than the Escort cars while operating on MMT. These trucks operate at higher loads and fuel flows than the Escorts. It is believed that these two factors when coupled with a more representative Ford driving schedule causes the truck HC non-compliance problem with MMT.

EXPLANATION OF DIFFERENCES BETWEEN FORD AND ETHYL TEST RESULTS

We believe the differences between Ethyl's and Ford's test results for the Escort HC data with clear fuel (non-MMT) is a result of the emission control system on the 1991 Escort vehicles used for Ford as compared to the Ethyl 1988 Escorts. The 1991 Escorts had better emission performance (lower deterioration) when operated on clear fuel than the 1988 Escorts. The 1991 Escort has state-of-the-art emission control systems which represent hardware needed to meet emission standards of the mid-1990s and more accurately reflect product designs which could be affected by an MMT waiver and employs sequential electronic fuel injection (SEFI) and mass air flow measurement. These two devices more accurately measure air flow and precisely meter fuel to each cylinder. These devices combined with distributorless ignition and an improved catalytic converter result in better overall emission performance. The 1988 Escorts used by Ethyl had one central fuel injector and did not use a precise air flow measurement device.

The differences in MMT-fueled emission results is a result of what we believe to be many factors. These factors have been previously outlined in MVMA's testimony at the Hearing. Ford data are more representative of the effects of MMT under real-life conditions: Ford's use of a mileage accumulation fuel (commercially-available additives) and driving schedule representative of actual customer usage; a break-in period for all vehicles to stabilize emissions; certification-representative emission control devices and system maintenance; the inclusion of all test data; conducting a much greater (six versus Ethyl's two or three) number of emission tests at each interval resulting in increased statistical confidence in the overall data and a 33-percent greater mileage accumulation and test interval per vehicle.

Conversely, we believe that the Ethyl data are flawed for the following reasons: Ethyl's use of a subjective decision process as to the number of tests performed at some test intervals creating a much less statistically significant overall data set at each interval; a subjective decision as to the inclusion of some test data; replacement of fuel injectors (not allowed under EPA certification regulations, and

adding variability to the test results); and the use of a mileage accumulation fuel which is not representative of commercially-available fuel as required by EPA certification protocol.

Regarding the Ford Explorer data, Ethyl did not test any trucks. We believe trucks should have been a part of Ethyl's fleet because of the reasons indicated under the section entitled "Ethyl's Lack of Inclusion of Trucks in its Test Programs."

In addition to the above, we believe Ethyl did not accumulate sufficient mileage. Their test vehicles should have accumulated at least 100,000 miles. As discussed under the section titled "Catalyst Efficiency Analysis and Other Observations", the greatest catalyst efficiency deterioration from the Ford test vehicles occurred between 50,000 and 100,000 miles. The Ethyl test fleet was stopped at 75,000 miles. We believe these vehicles would have demonstrated greater HC deterioration in the 75,000 to 100,000-mile interval.

TOXIC EMISSIONS FROM VEHICLES USING MMT GASOLINE

The emission levels of formaldehyde, 1,3-butadiene, benzene and toluene tended to follow the total HC emissions, which were also higher for the MMT vehicles than for the clear fuel vehicles. The results of these tests are attached.

EMISSION CONTROL DEVICE FUNCTIONAL ANALYSIS AND VISUAL INSPECTION TEST RESULTS

FUNCTIONAL ANALYSIS

A functional analyses of EGO sensors and catalysts from two of the Escorts has been completed. The testing of Explorer vehicles is in process and should be completed by mid-October. The functional analysis testing consists of interchanging EGO sensors and catalysts between the non-MMT or clear-fueled vehicles and the MMT-fueled vehicles. The test sequence consisted of running three emissions tests with interchanged EGO sensors, three with interchanged catalysts, and three with interchanged EGO sensors and catalysts. The comparison baseline used was the data already obtained at the 100,000-mile point (an average of six tests).

The summarized tailpipe emission results from Escort vehicles #315 (clear fuel) and #316 (MMT fuel) are as follows: vehicle #315 -- 66 percent increase in HC (with #316 EGO sensor and catalyst), 6 percent decrease in CO and 24 percent increase in NO_x; vehicle #316 -- 45 percent decrease in HC (with #315 EGO sensor and catalyst), 14 percent decrease in CO and 2 percent decrease in NO_x.

Plots of the data from this component functional testing are included as attachments.

Testing with the clear-fueled EGO sensor and catalyst on MMT-fueled vehicle #316 reduces its HC level from 0.31 gm/mi to 0.17 gm/mi. It is interesting to note that the 0.17 gm/mi value is the same HC value that the clear-fueled vehicle #315 had at 100,000 miles. These test results demonstrate that MMT has significantly impaired the function of emission control devices (EGO sensors and catalysts).

We are in the process of testing the Explorers. The Explorers were more negatively impacted (higher deterioration for HC) by the MMT than the Escorts. It is believed that the functional component testing of these Explorer vehicles will have a greater negative result from the MMT than that shown on the Escorts.

VISUAL INSPECTION

A visual inspection of the catalyst removed from the Explorer trucks which had the greatest HC increases with MMT showed a thick layer of Mn_3O_4 covering the washcoat and total plugging from 10 to 15 percent of the inlet face cells. Attached is a picture of both an MMT-fueled vehicle catalyst and a non-MMT catalyst. The same thick layer was observed on the EGO sensors removed from the MMT-fueled vehicles.

The results of our visual inspection corroborate the findings from our inspection of catalysts removed from Canadian vehicles [reference our July 23, 1990 communication to Air Docket (LE-131)]. The very high HC levels on the Explorers support our claim that the Mn_3O_4 layer which covers the washcoat slows the diffusion of gas so that conversion rates are reduced. A similar contamination of the EGO sensor reduces its function, as discussed above.

CATALYST EFFICIENCY ANALYSIS AND OTHER OBSERVATIONS

As noted in our July 23 and October 29, 1990 communications to the Docket No. A-90-16, we have evaluated catalysts from Canadian vehicles. We believe the data obtained from these evaluations are applicable for the current Ethyl waiver application MMT level, as the level of MMT in Canadian fuel typically is only 21% to 42% higher than the MMT concentration requested in the waiver. These Canadian vehicle evaluations included catalyst warranty returns, Ford employee vehicle inspections and diagnostics data from vehicles returned to Dealerships with poor driveability. As previously indicated in the referenced communications, these Canadian vehicle catalyst evaluations, inspection and diagnostics all revealed Mn_3O_4 deposit build-up. This deposit build-up results in reduced catalyst efficiency.

A pulsator aging study was carried out using a TWC to determine the effect of the MMT fuel additive on the performance of the catalyst. The pulsator is set up to evaluate a small plug of catalyst. It will accelerate the evaluation process because of the sample size. In this study, a fully-formulated unleaded gasoline doped with Ethyl's HiTEC 3000 at a concentration level of 1/32 gram Mn/gallon was used for catalyst aging. These results were compared to a catalyst aged concurrently with the same fuel not having the MMT additive. The catalysts were aged to 15,000 miles on a pulse flame combustor.

At the end of 15,000 miles of aging, the results (Figure 1) show the MMT-aged catalyst to have 16% lower CO conversion than that of the non-MMT aged catalyst. The difference in HC, although, was less pronounced at lower mileage(<10,000 miles). At about 10,000 miles, however, the MMT-aged catalyst started to show a sharper decline in HC conversion. At the end of 15,000 miles of aging, the MMT-aged catalyst shows 6 percent lower HC conversion than its non-MMT aged counterpart (Figure 1). A 6 percent lower HC conversion efficiency (from 80 to 74 percent) would result in a 30 percent increase in tailpipe HC levels (1-.74)/(1-.80). Catalyst light-off temperatures for both HC and CO also increased significantly in the catalyst aged with MMT as compared to its non-MMT aged counterpart (Figures 2, 3).

In summary, the laboratory test results show that the addition of MMT in a fully-formulated gasoline at a concentration as low as 1/32 gram Mn/gallon caused significant deterioration in HC and CO conversion efficiency and increased the light-off temperatures for HC an CO. For HC, in particular, the sharp increase in catalyst light-off temperature with exposure to MMT could be expected to result in lower Bag 1 FTP conversion efficiency.

In addition to the above outlined laboratory studies, an analysis of the catalyst efficiencies for HC from the eight-vehicle fleet has been completed. Attached are the results of the analysis. Both the clear and MMT-fueled vehicles start out with the same average HC catalyst efficiency of 92 percent after 15,000 miles. As mileage continues, the MMT catalyst efficiency deteriorates by one percentage as compared to the clear vehicle after 50,000 miles. The greatest deterioration takes place between 50,000 and 100,000 miles where the MMT-fueled vehicles lose an additional six percent efficiency as compared to the clear. This overall loss in efficiency of seven percent would result in a 60 percent increase in tailpipe HC levels.

These results indicate the greatest catalyst deterioration after 50,000 miles. Considering that Ethyl's test fleet accumulated only 75,000 miles and they replaced all fuel injectors at 50,000 miles (which is not permitted under EPA certification testing regulations), probably means it does not fully reflect the adverse effect of MMT. Additionally, Ethyl's higher speed mileage accumulation on the two Corvettes and two Crown Victorias was for 35,000 miles or less. As a result, it is not surprising to Ford that these four vehicles did not experience catalyst problems.

The Ford data indicate catalyst problems do not occur until after 50,000 miles. The 50,000-mile point is much less than the light-duty truck useful life of 120,000 miles which has been in effect since 1985. As noted earlier, light-duty trucks make up almost half of the new vehicle sales in the United States and should have been evaluated by Ethyl.

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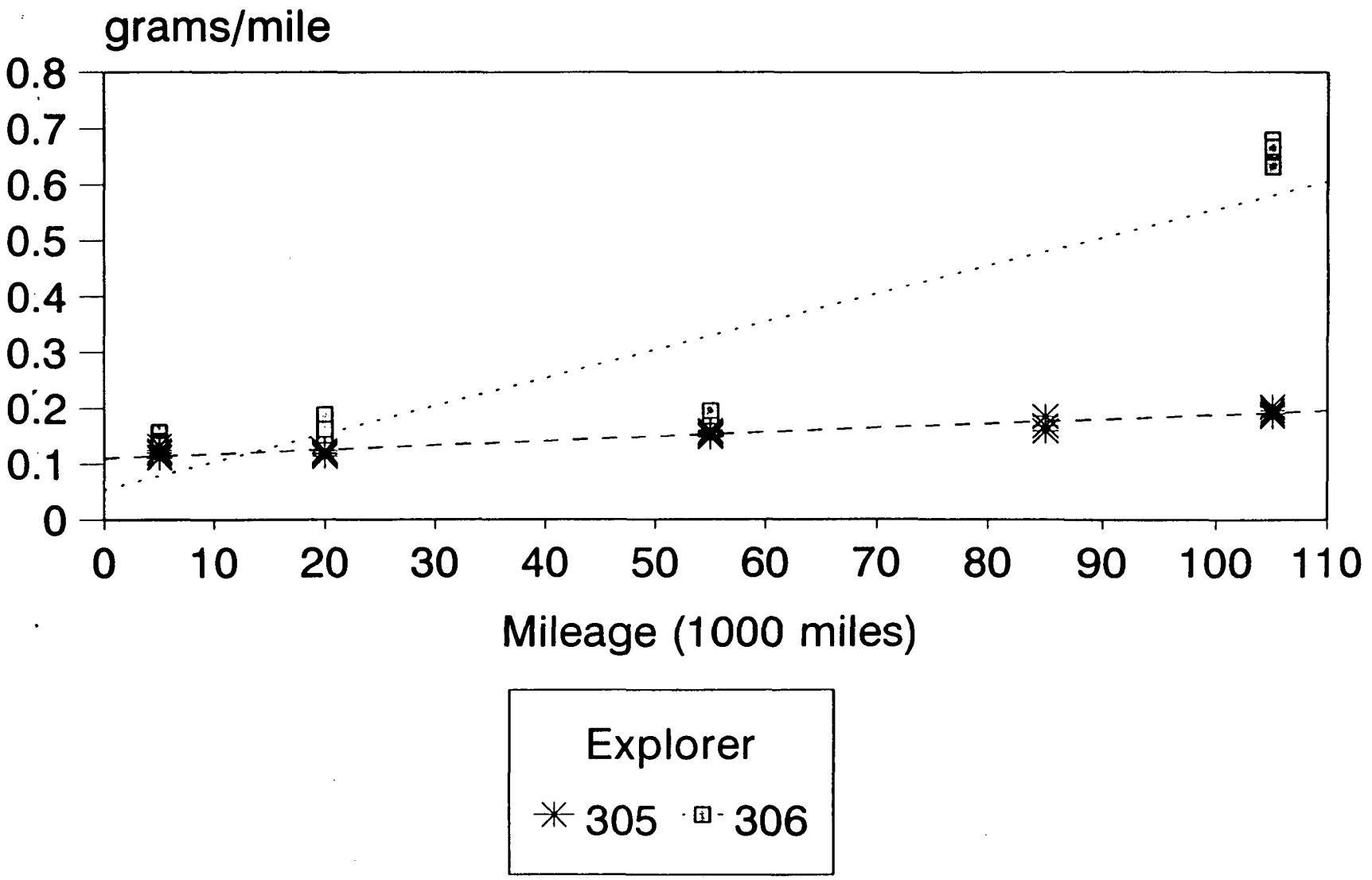
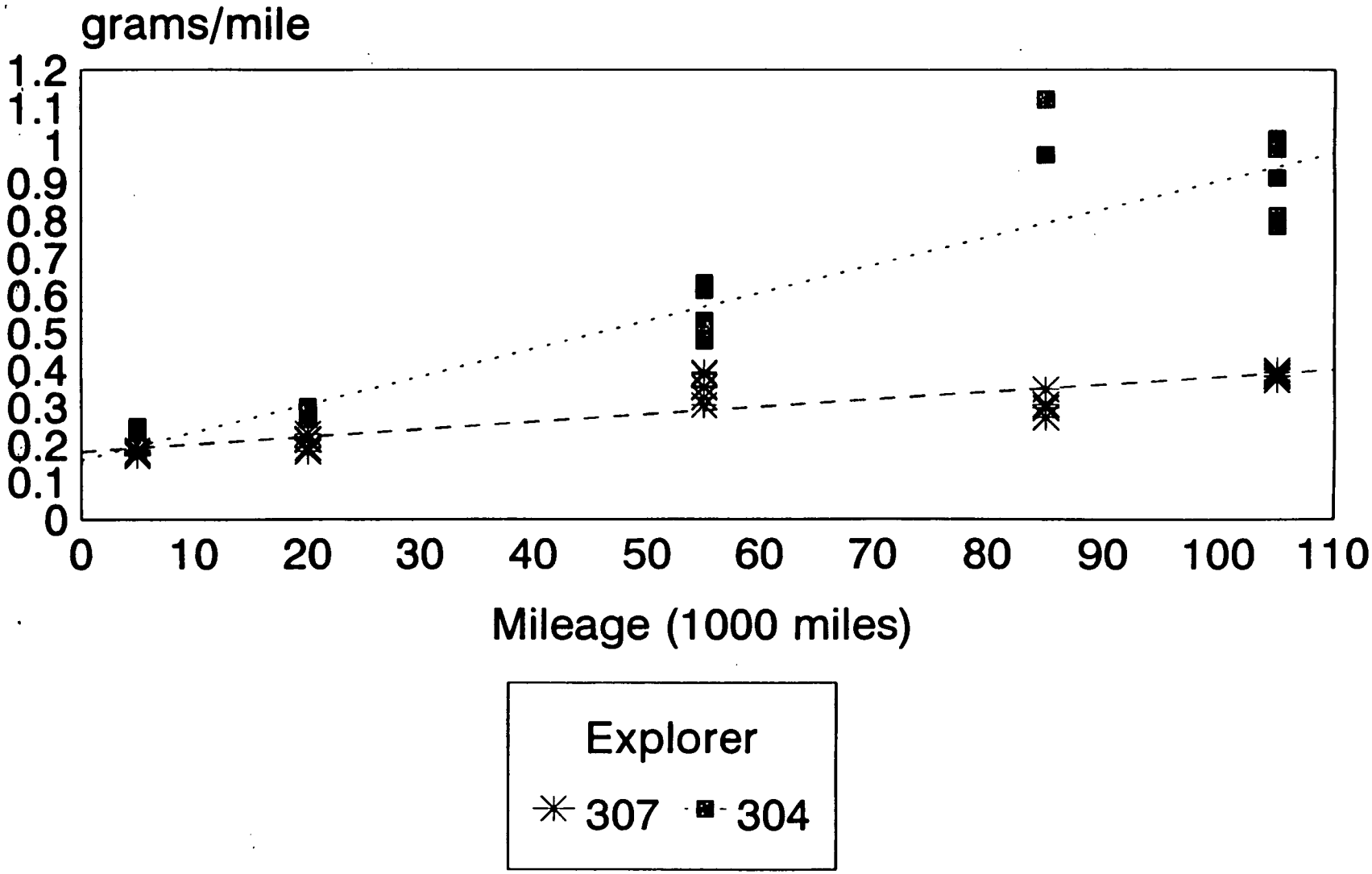
Explorer Fleet
HC Tailpipe Emissions



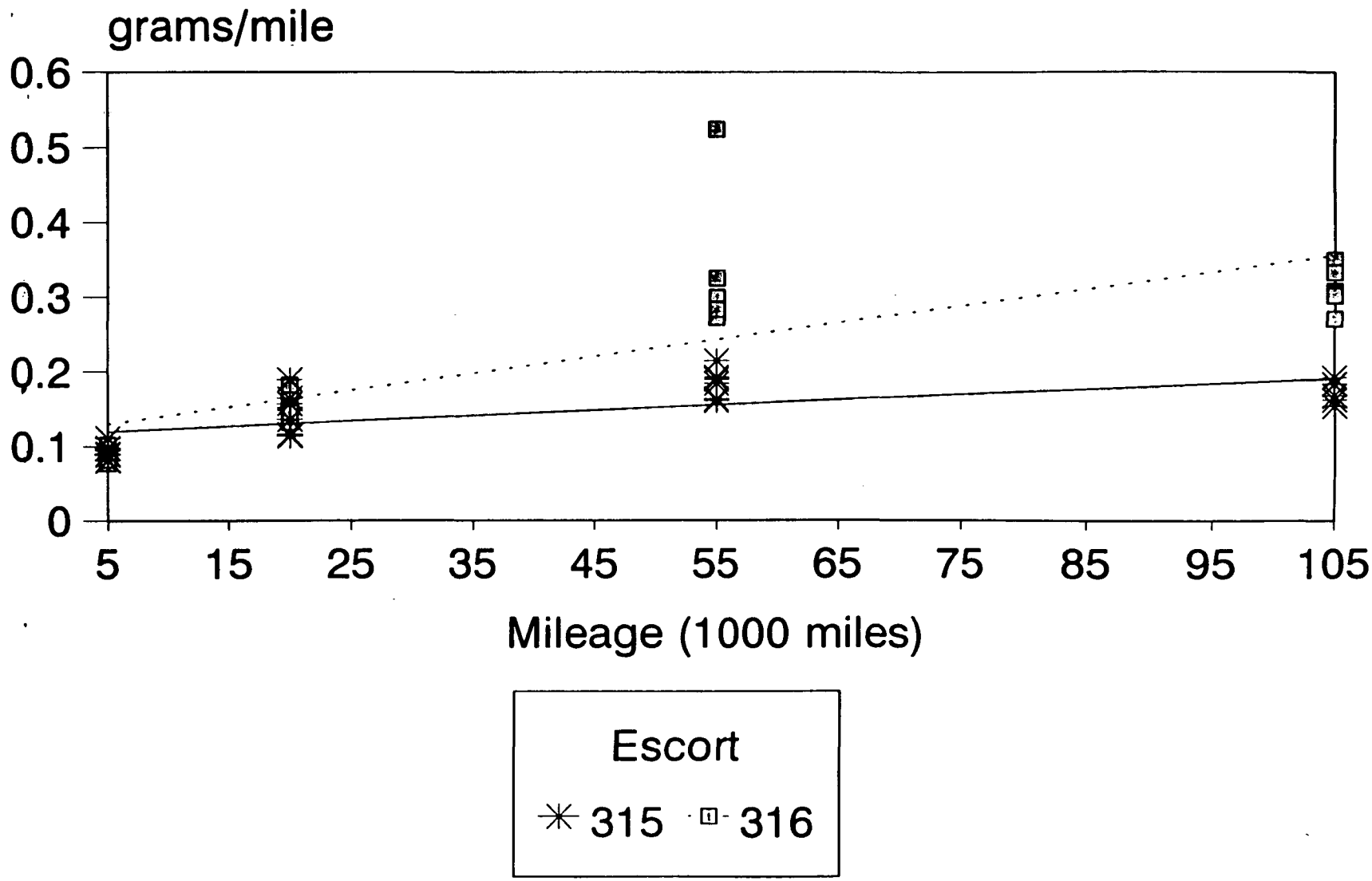
305- Non-MMT Fuel
306- MMT Fuel

Explorer Fleet
HC Tailpipe Emissions



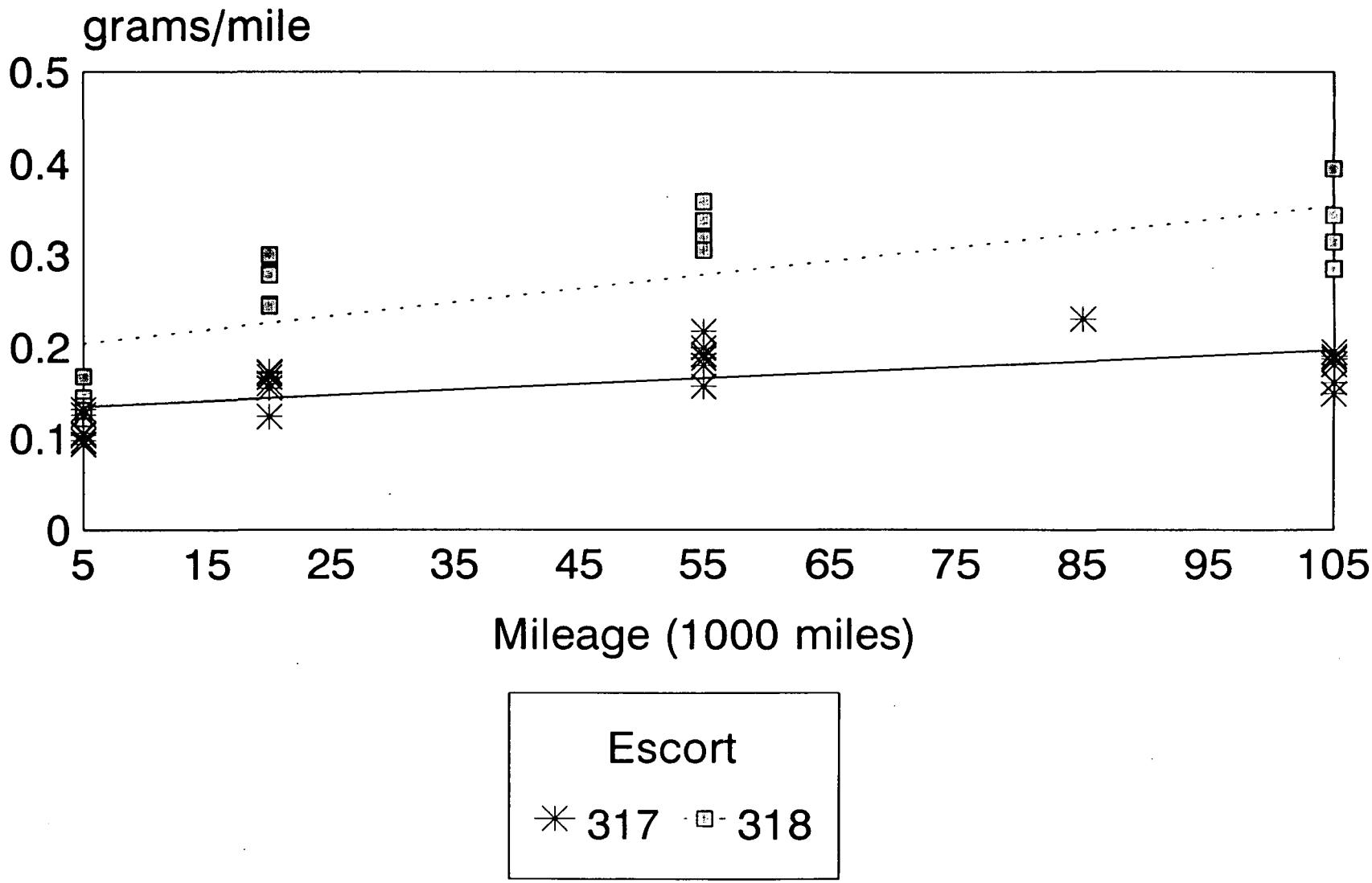
307- Non-MMT Fuel
304- MMT Fuel

Escort Fleet
HC Tailpipe Emissions



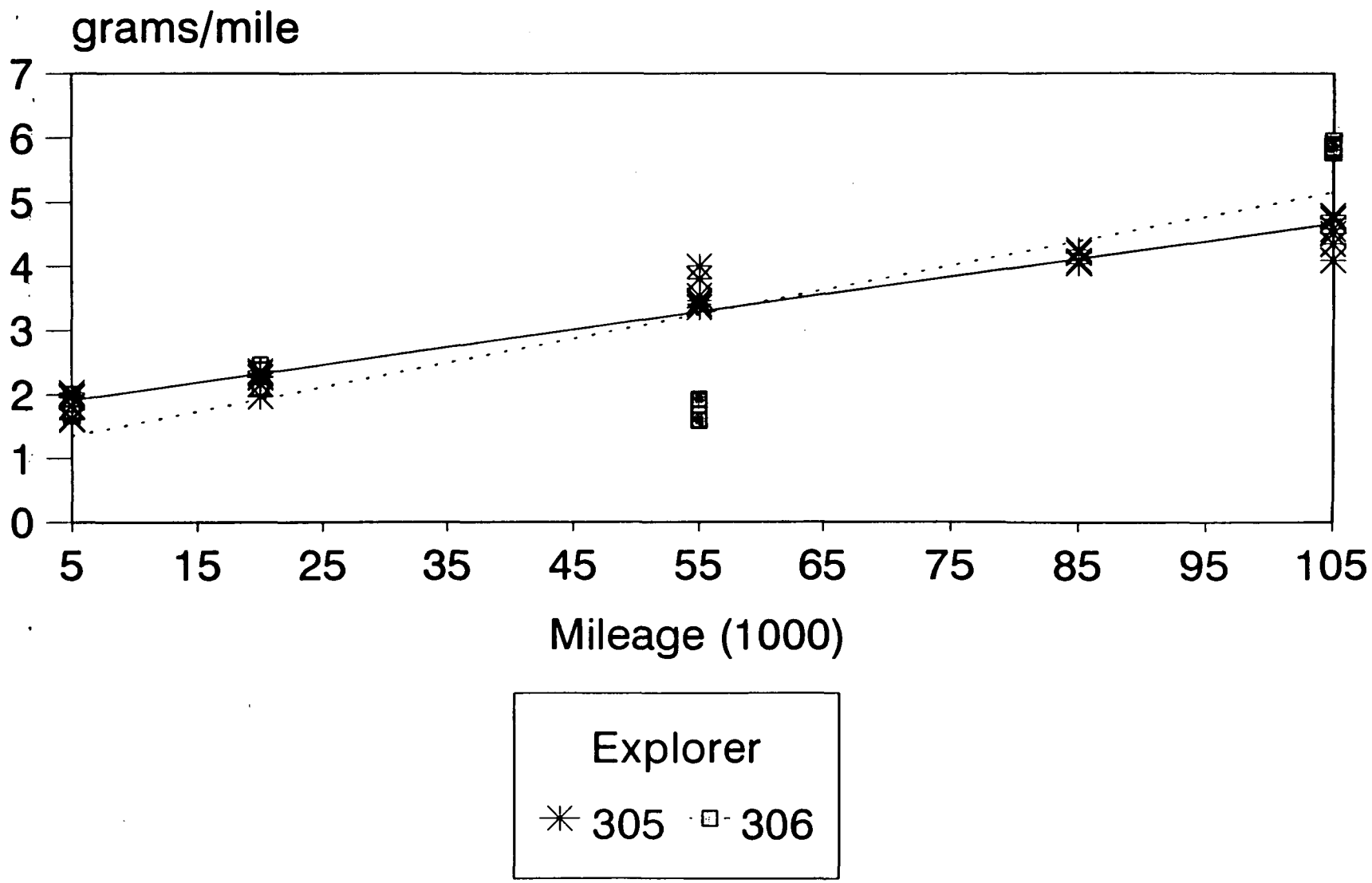
315- Non-MMT Fuel
316- MMT Fuel

Escort Fleet
HC Tailpipe Emissions



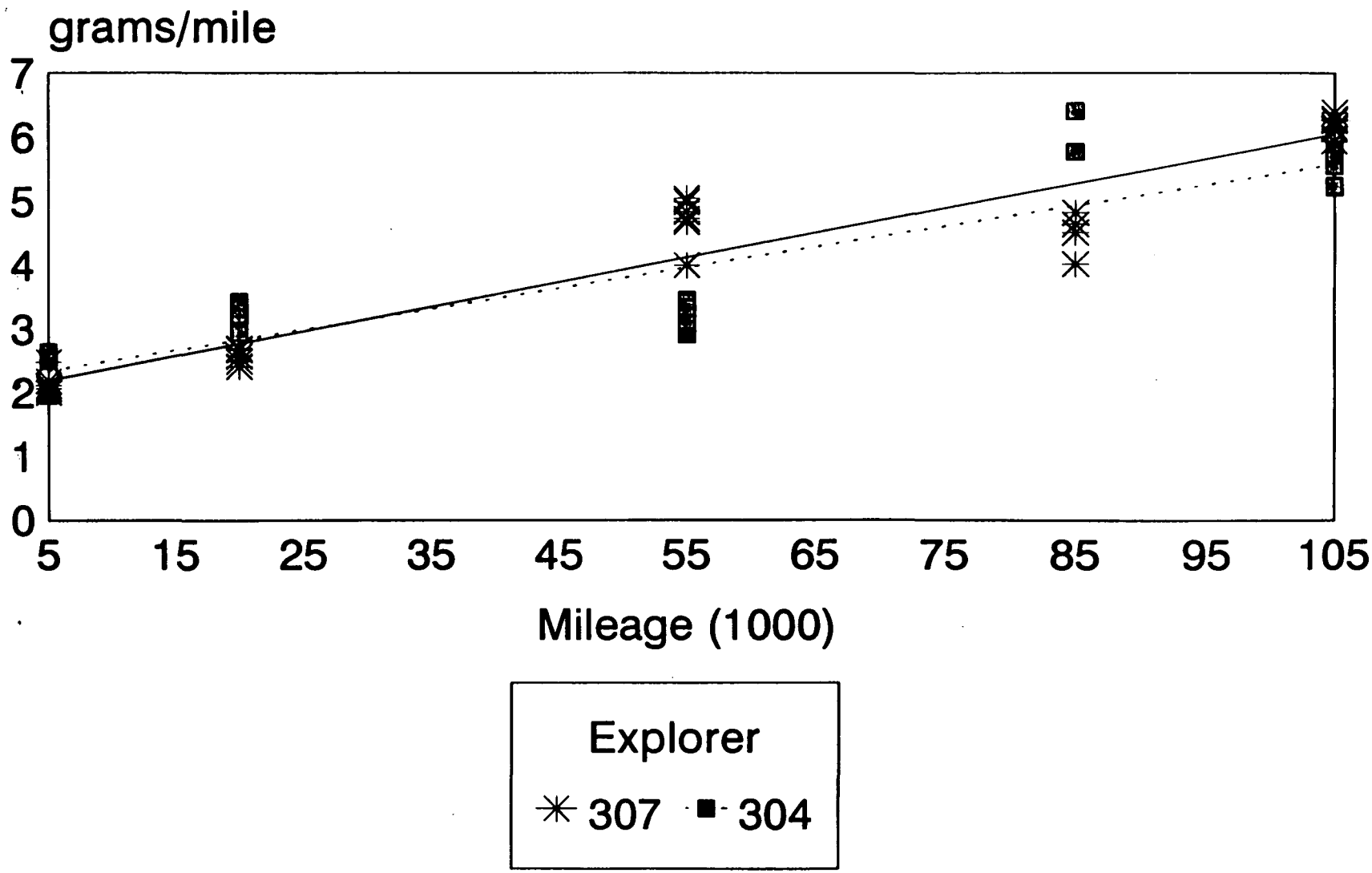
317- Non-MMT Fuel
318- MMT Fuel

Explorer Fleet
CO Tailpipe Emissions



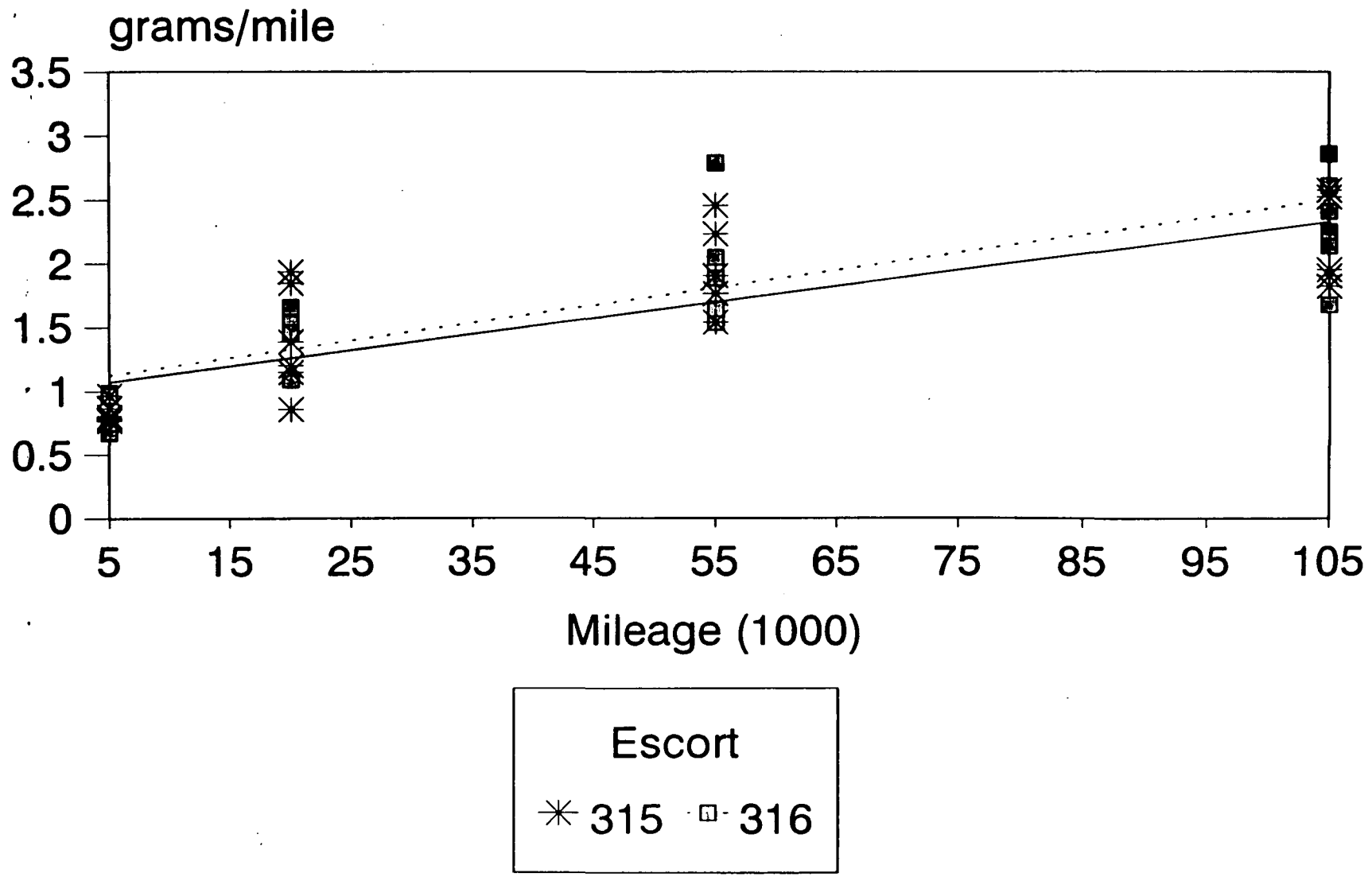
305- Non-MMT Fuel
306- MMT Fuel

Explorer Fleet
CO Tailpipe Emissions



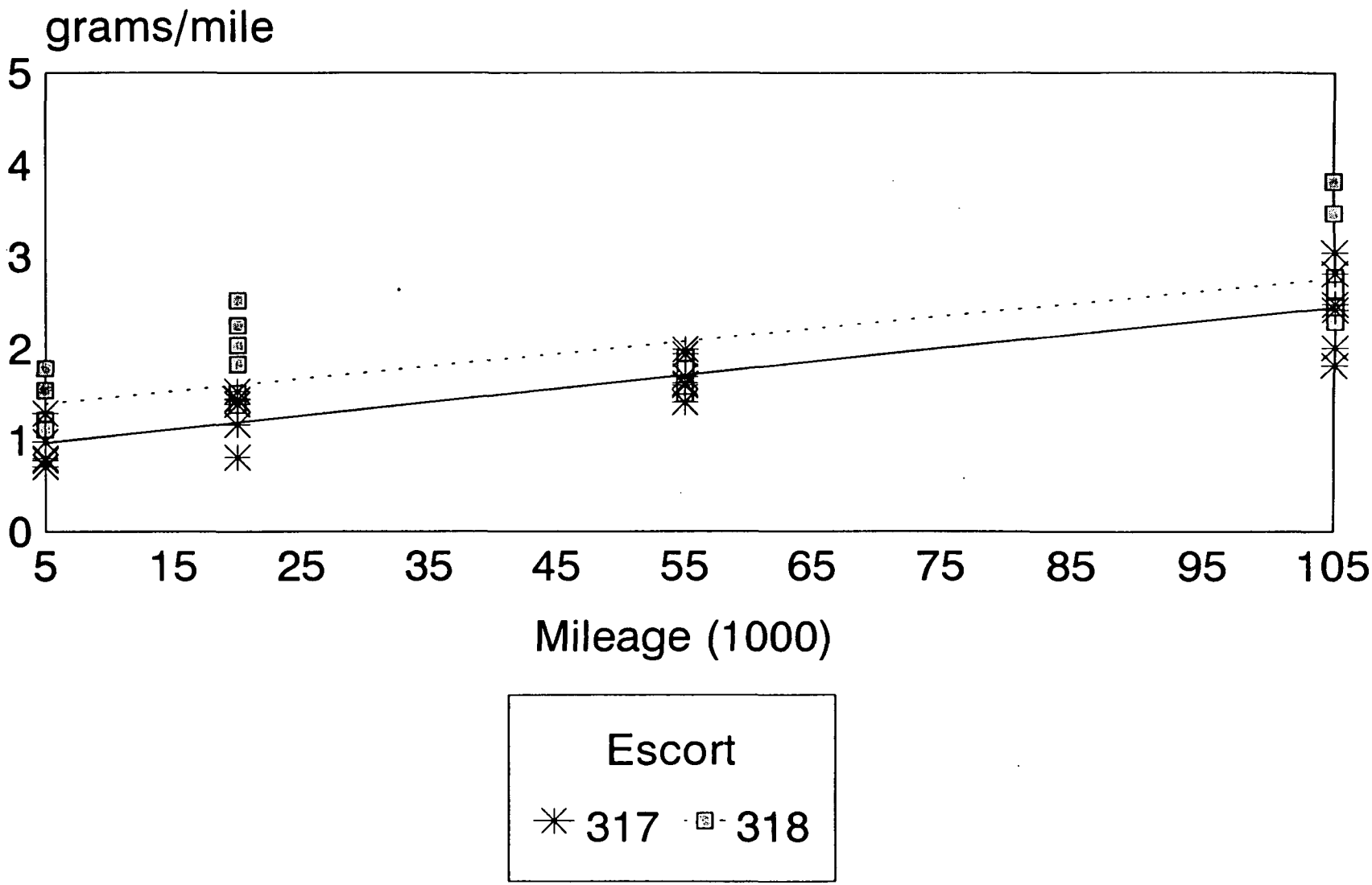
307- Non- MMT Fuel
304- MMT Fuel

Escort Fleet
CO Tailpipe Emissions



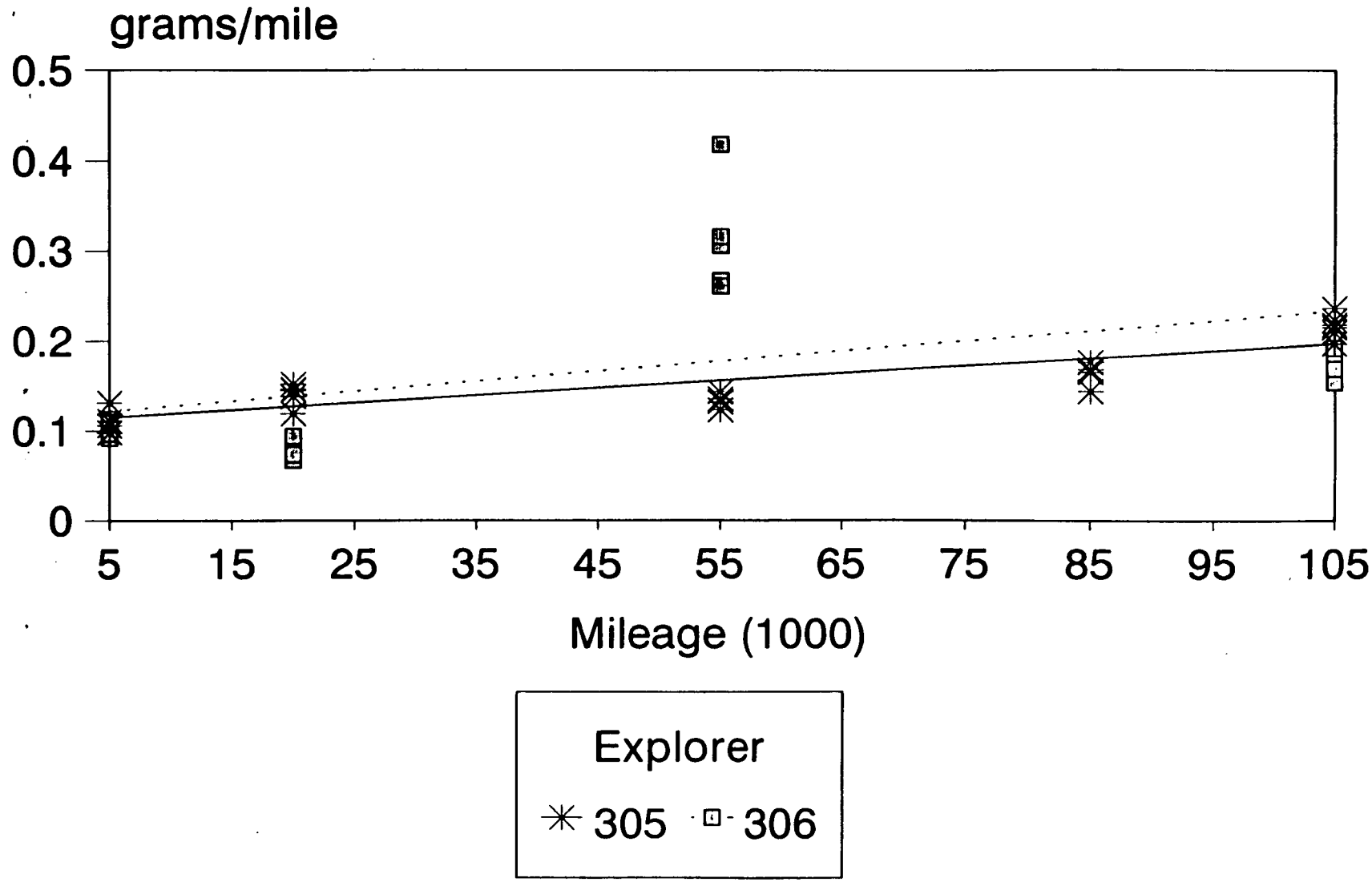
315- Non-MMT Fuel
316- MMT Fuel

Escort Fleet
CO Tailpipe Emissions



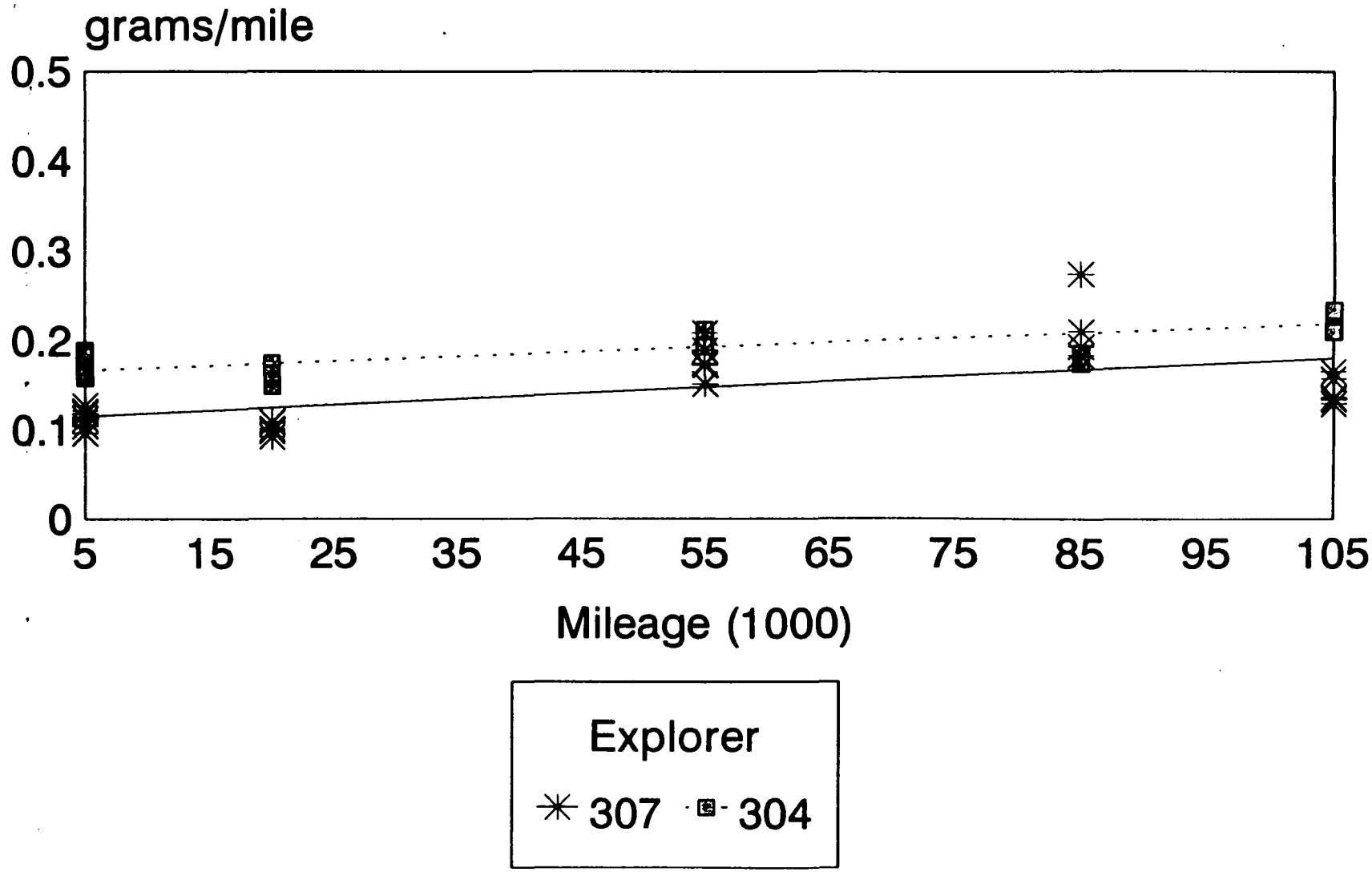
317- Non-MMT Fuel
318- MMT Fuel

Explorer Fleet
NOx Tailpipe Emissions



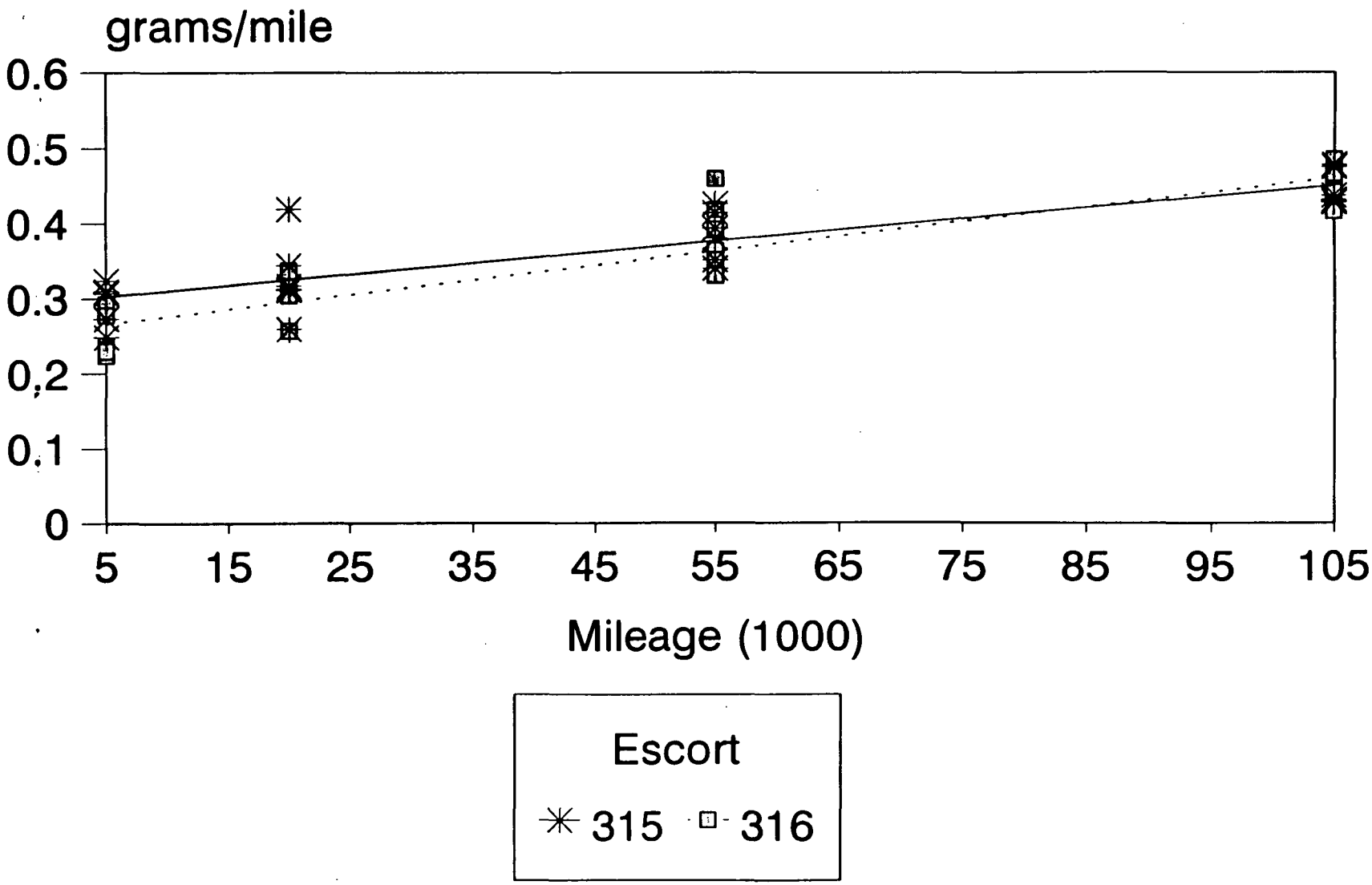
305- Non-MMT Fuel
306- MMT Fuel

Explorer Fleet
NOx Tailpipe Emissions



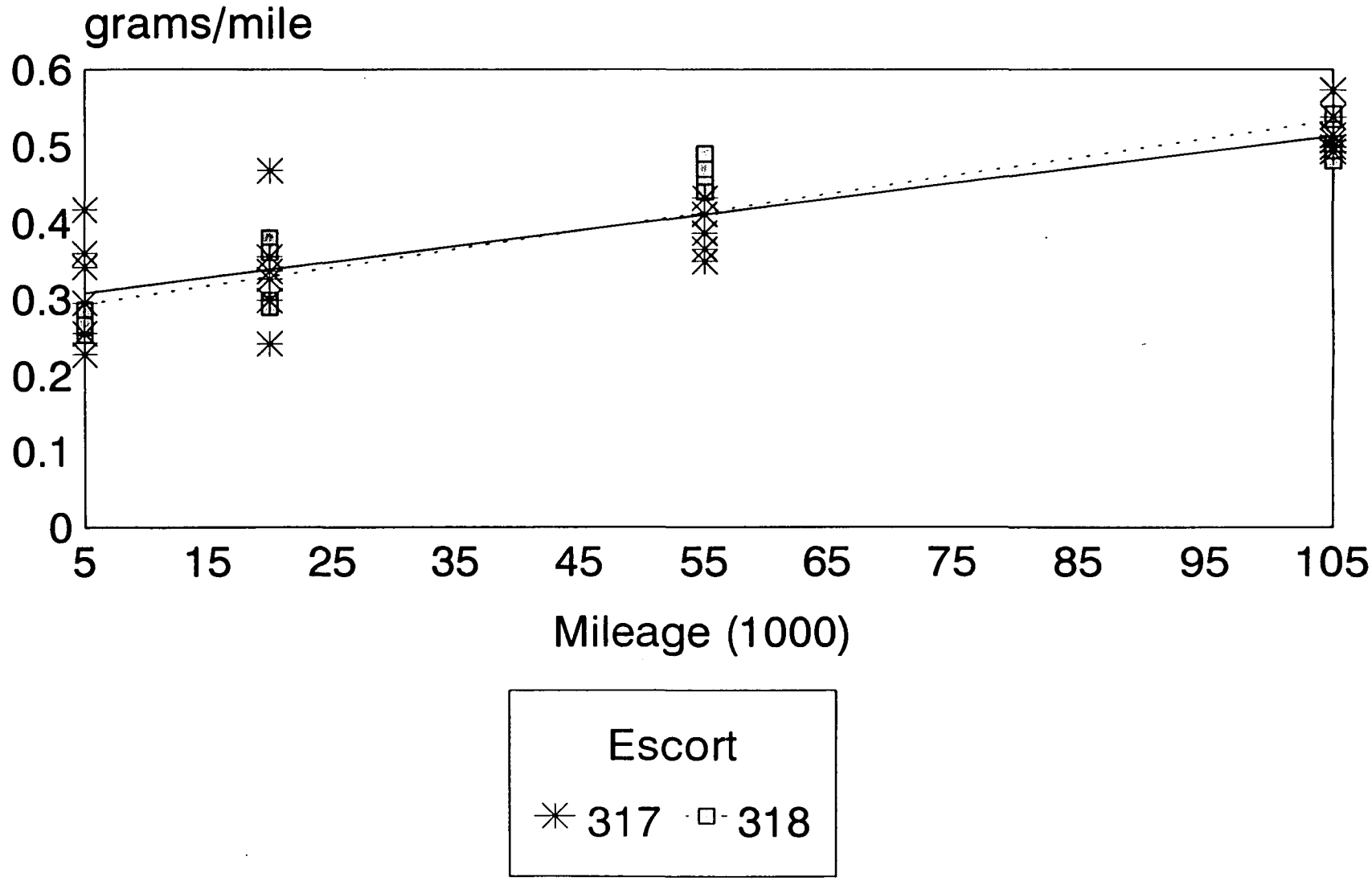
304- MMT Fuel
307- Non-MMT Fuel

Escort Fleet
NOx Tailpipe Emissions



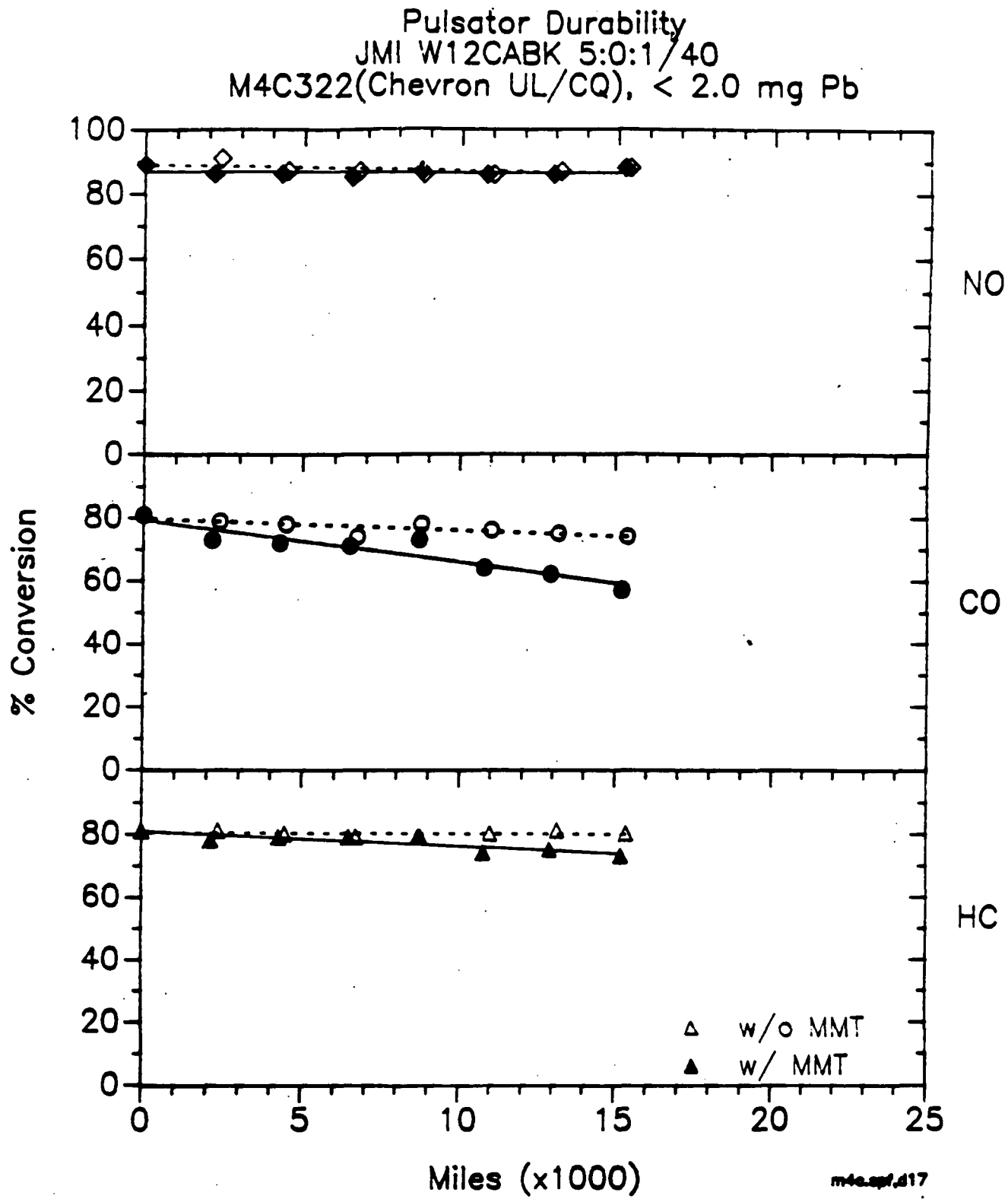
315- Non-MMT Fuel
316- MMT Fuel

Escort Fleet
NOx Tailpipe Emissions



317- Non-MMT Fuel
318- MMT Fuel

Figure 1


Pulsator Durability
JMI W12CABK 5:0:1/40
M4C322(Chevron UL/CQ), < 2.0 mg Pb
% Conversion
NO
CO
HC
w/o MMT
w/ MMT
Miles (x1000)
m4c.spf,d17

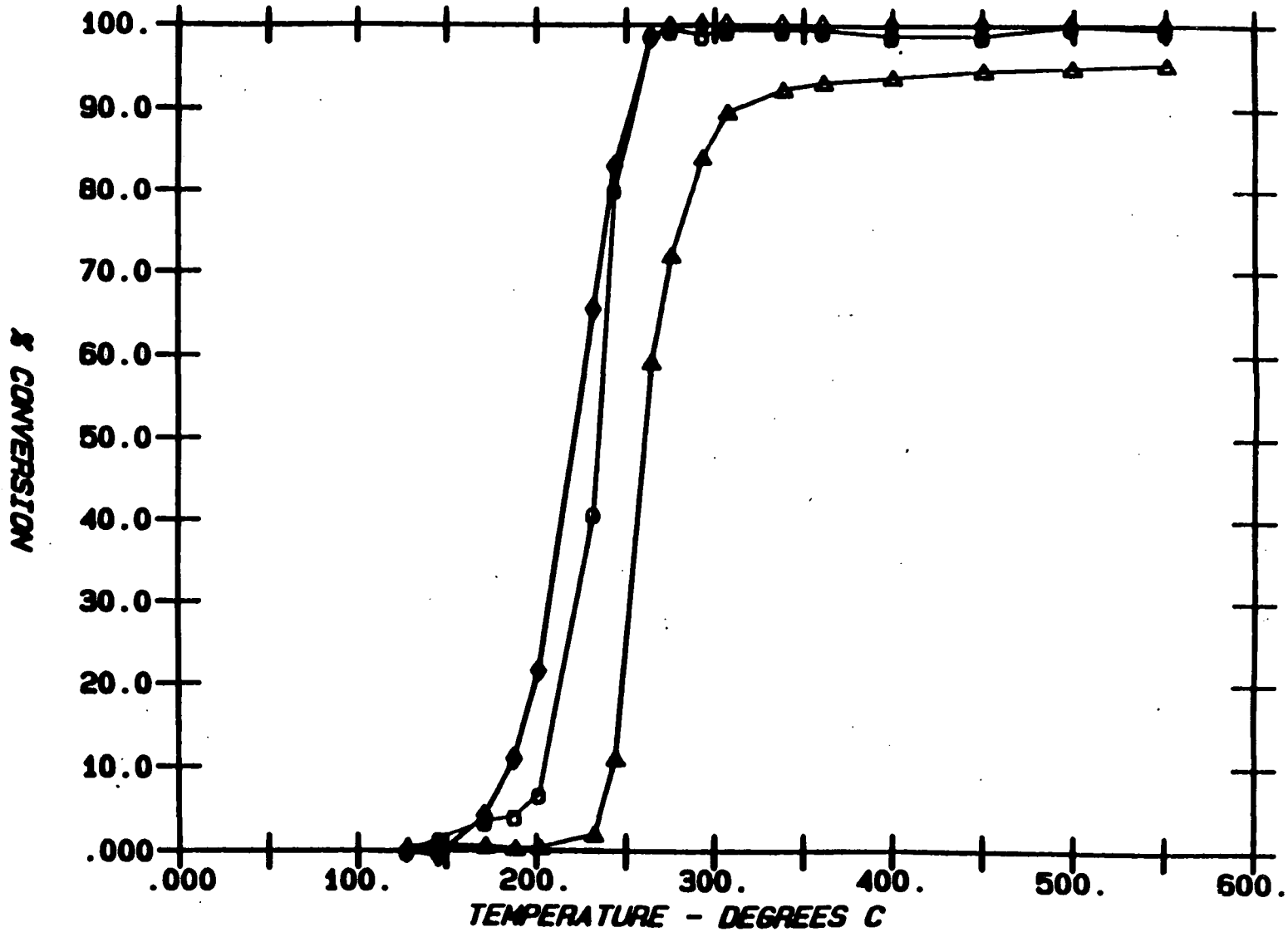
FIGU.. 2

xE 0

JMI ON 16885 PULSATOR 15,390 MILES

(Without MMT)

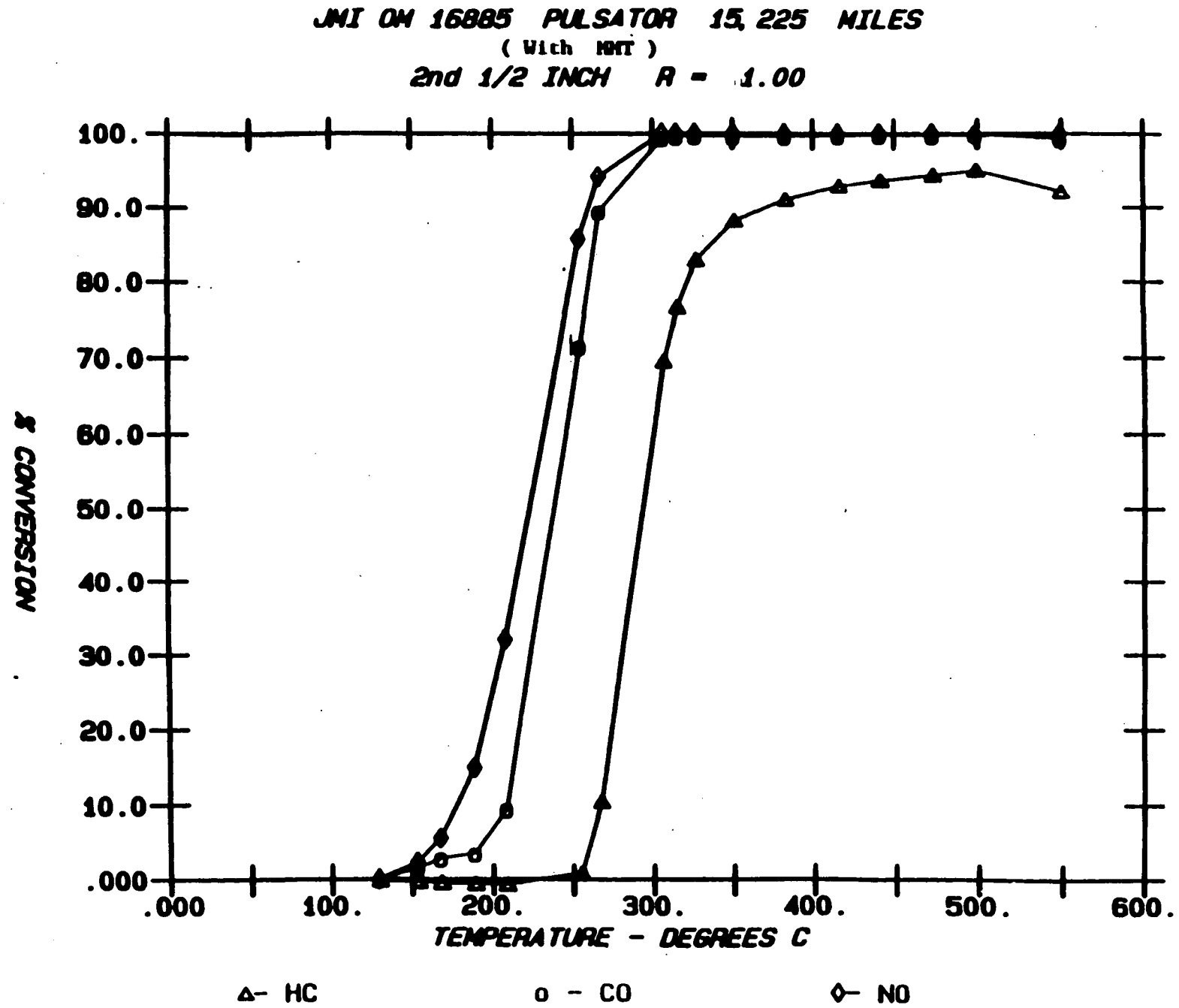
2nd 1/2 INCH R = 1.00



xE 0

FIGURE 3

xE 0



xE 0

Toxic Emissions from Vehicles Using MMT Gasoline

by
R. H. Hammerle, T. J. Korniski and E. Chladek
Research Staff
Ford Motor Company
Dearborn, Michigan 48121

The non-regulated emissions have been measured as a function of mileage for four Escort and four Explorer vehicles using both MMT gasoline at 1/32 g Mn/gal and MMT-free gasoline. These measurements were part of the larger Ford program to measure the effect of MMT use on regulated, particulate and manganese emissions. Generally, the emissions of formaldehyde, 1-3 butadiene, benzene and toluene were larger from the vehicles using MMT-gasoline than from those using MMT-free fuel (Table 1). The emission levels of these compounds tended to follow the total HC emissions, which were also larger for the MMT vehicles than for the MMT-free vehicles.

As background information, formaldehyde, 1,3 butadiene, benzene and toluene emissions from current vehicles in the Auto/Oil program averaged about 2 mg/mi, 1 mg/mi, 6 mg/mi and 20 mg/mi, respectively. In 1989, Adler and Carey ("Air Toxics Emissions and Health Risks from Mobile Sources," 82nd Annual Meeting of the Air and Waste Management Association, June 25-30, 1989) of the EPA projected that vehicles in-use in 1995 would emit 17 mg/mi formaldehyde, 5 mg/mi 1,3 butadiene and 66 mg/mi benzene.

Table 1

Effect of MMT on Toxic Emissions

Vehicles Odometer miles	Formaldehyde		1,3 Butadiene		Benzene		Toluene	
	MMT mg/mi	Without mg/mi	MMT mg/mi	Without mg/mi	MMT mg/mi	Without mg/mi	MMT mg/mi	Without mg/mi
Explorers #306,#305 5,000	0	1						
20,000	0	0	0.6	0.3	9.1	3.1	12.7	6.8
55,000	2	1	0.7	0.6	7.2	6.1	11.3	9.4
85,000	1	0	1.5	0.6	43.3	7.1	50.4	17.3
105,000	3	0						
Escorts #316,#315 5,000	0	1						
20,000	2	1	1.3	0.5	17.8	8.6	13.5	8.9
55,000	0	2	1.8	0.4	18.9	8.6	12.0	11.9
85,000	0	0	1.8	1.5	19.2	18.4	12.4	13.4
105,000		0						

HC EFFICIENCY COMPARISON

MMT VEHICLES

Vehicle Number	15K	50K	100K	Feedgas @ 100K
304	.91	.86	.76	(3.70)
306	.94	.94	.80	(3.26)
316	.93	.85	.84	(1.97)
318	.88	.85	.85	(2.13)
AVERAGE	.92	.88	.81	

CLEAR VEHICLES

Vehicle Number	15K	50K	100K	Feedgas @ 100K
305	.94	.92	.90	(1.95)
307	.91	.86	.83	(2.25)
315	.92	.90	.91	(1.93)
317	.91	.89	.89	(1.70)
AVERAGE	.92	.89	.88	

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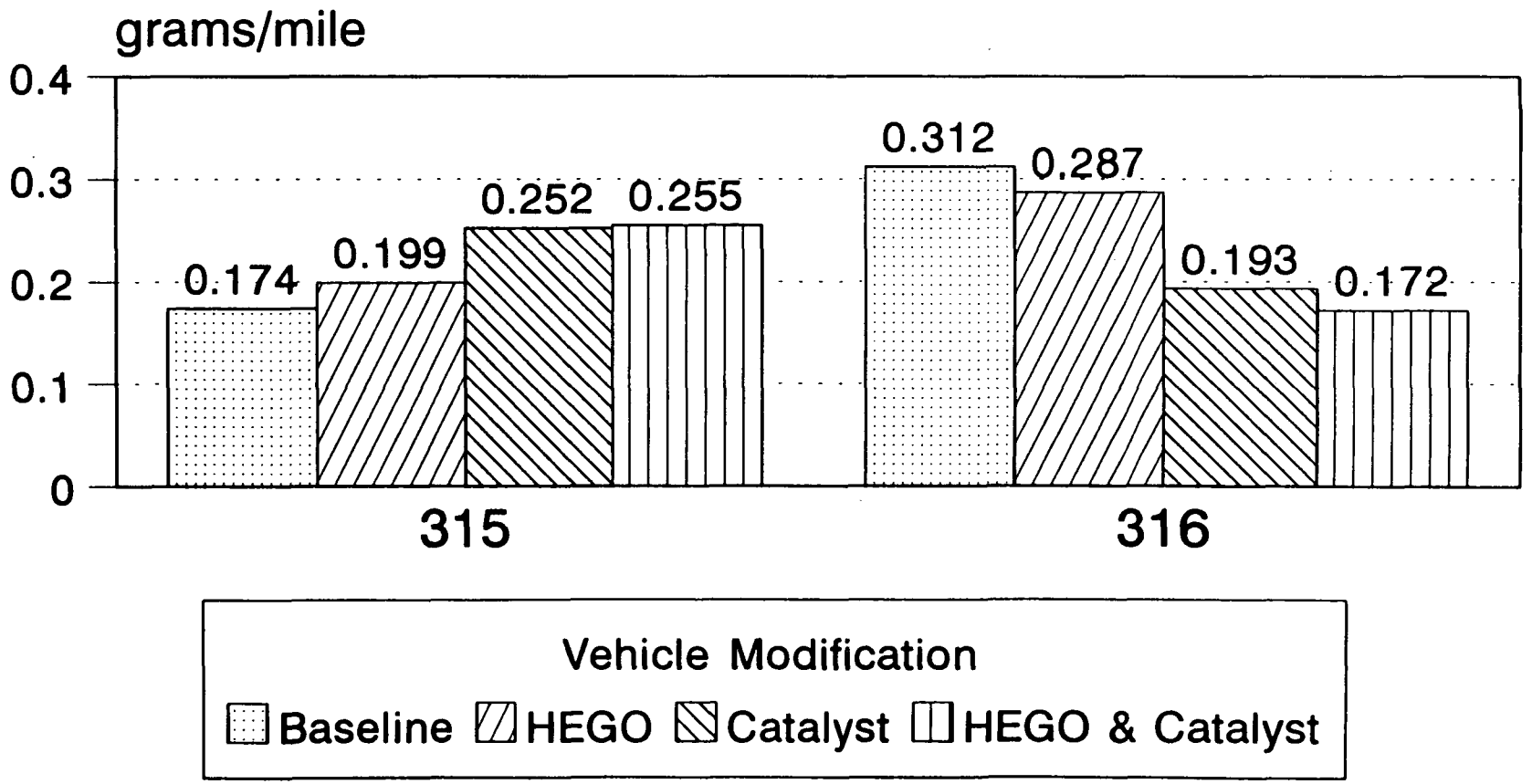
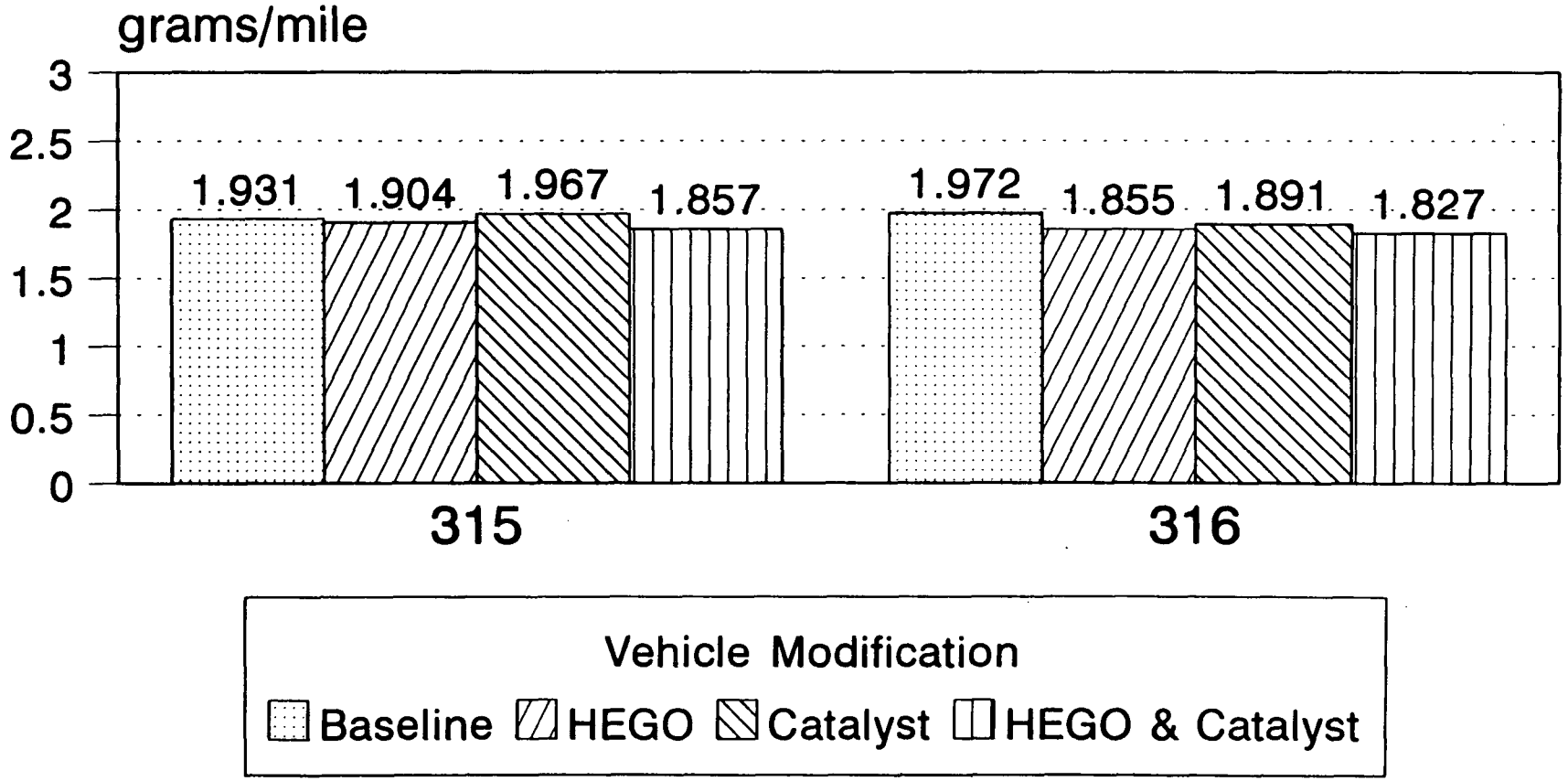
HC Tailpipe Emissions
Escort Fleet



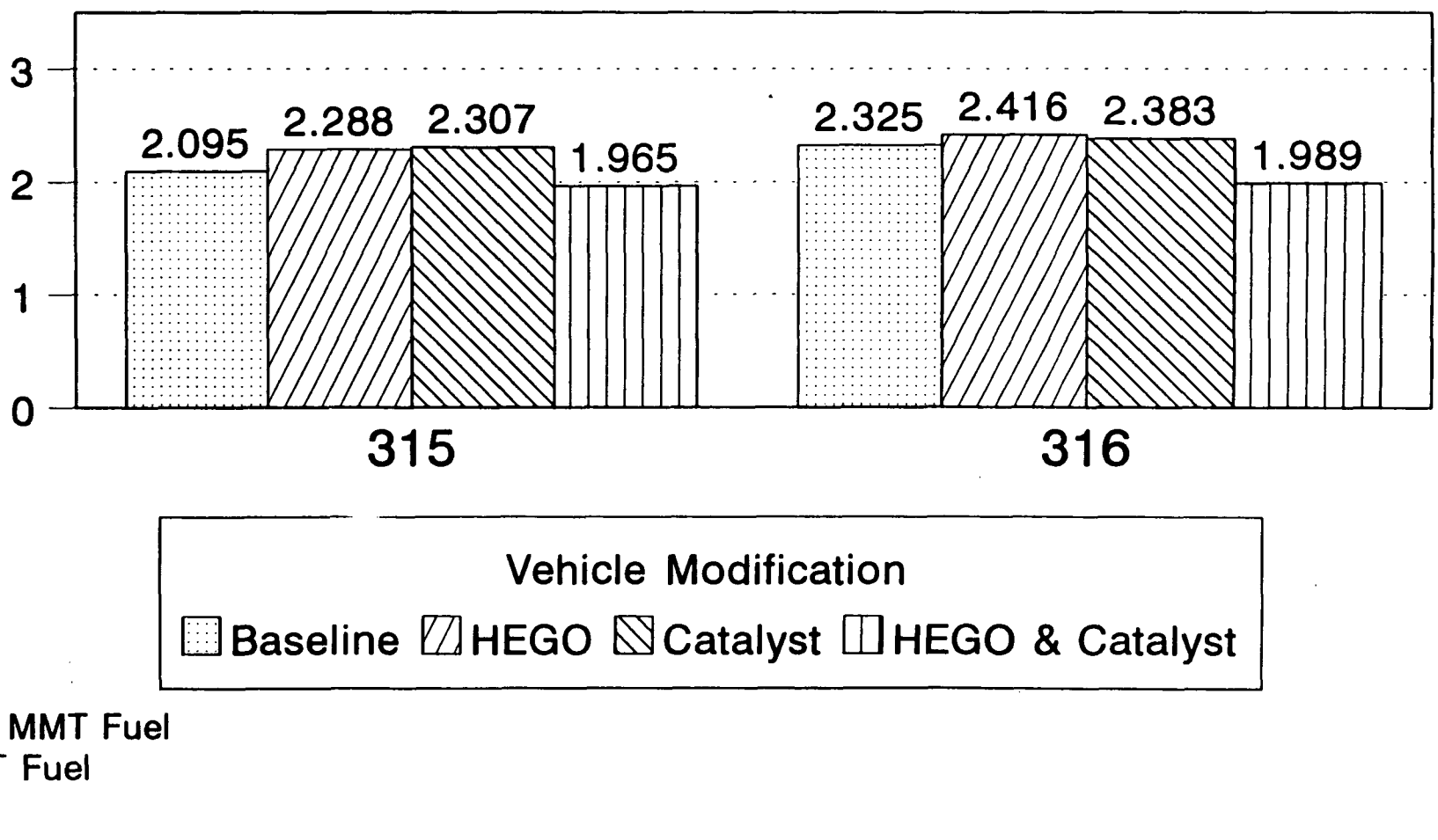
315- Non MMT Fuel
316- MMT Fuel

HC Feedgas Emissions
Escort Fleet



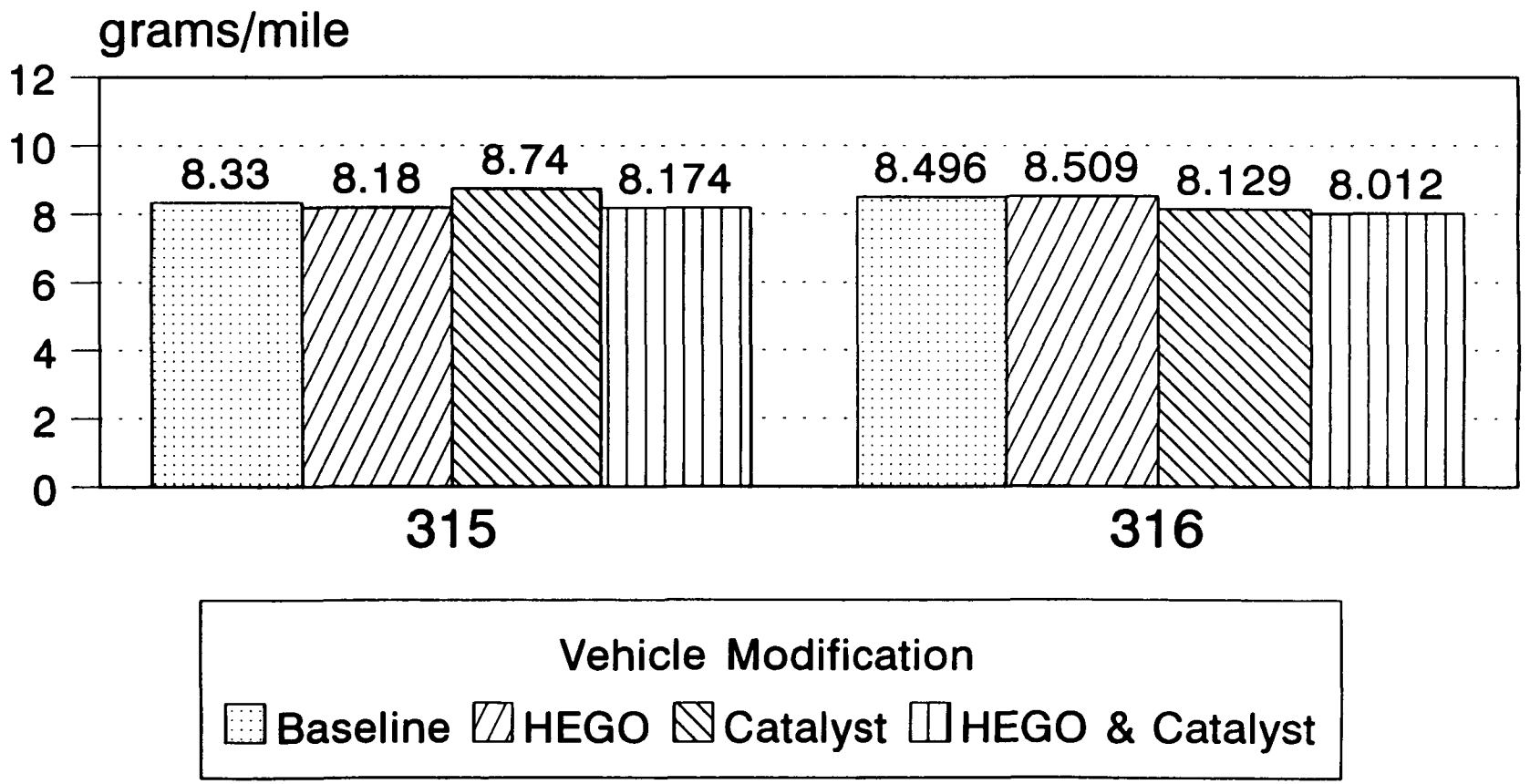
315- Non MMT Fuel
316- MMT Fuel

CO Tailpipe Emissions
Escort Fleet



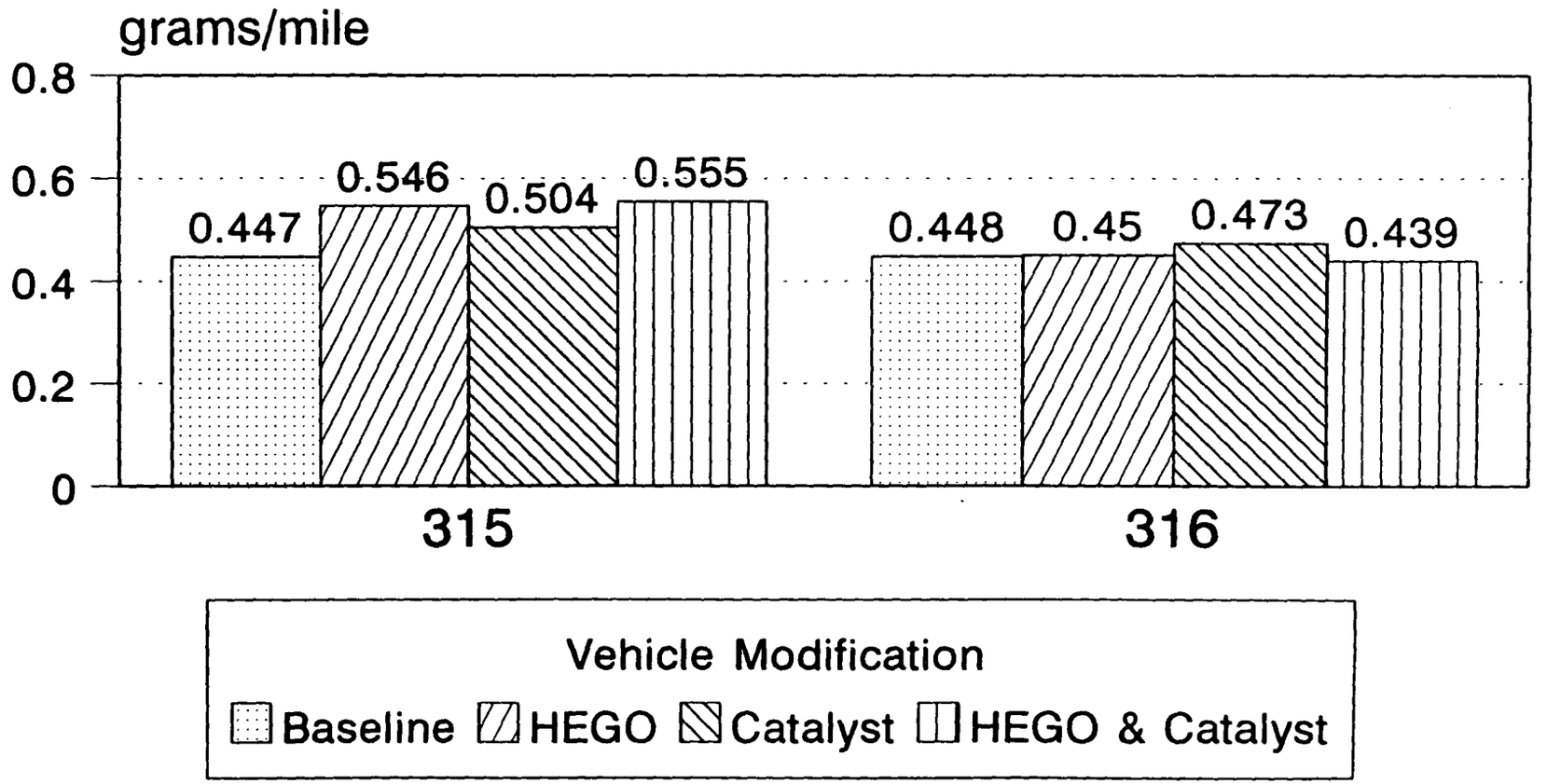
315- Non MMT Fuel
316- MMT Fuel

CO Feedgas Emissions
Escort Fleet



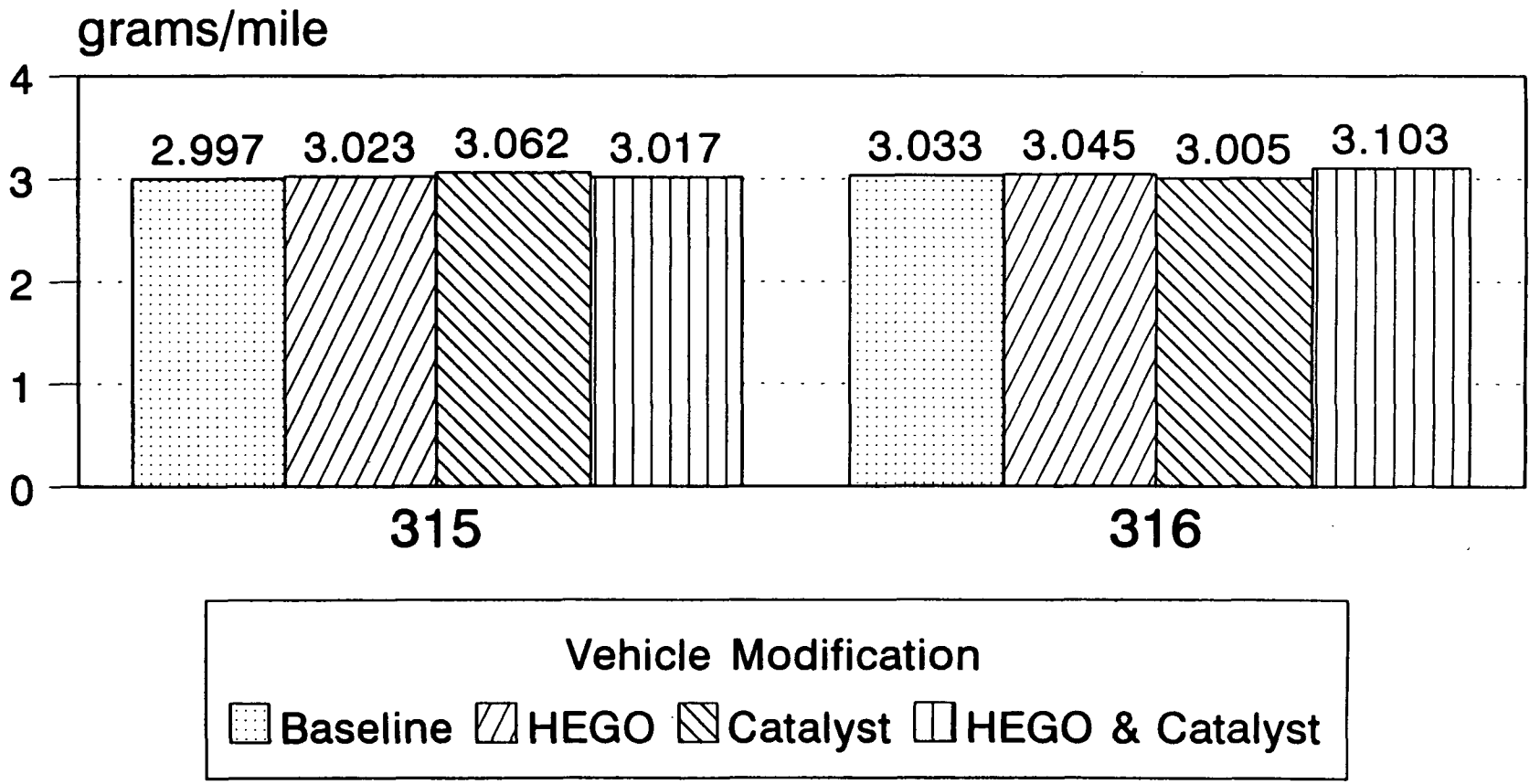
315- Non MMT Fuel
316- MMT Fuel

NOx Tailpipe Emissions
Escort Fleet



315- Non MMT Fuel
316- MMT Fuel

NOx Feedgas Emissions
Escort Fleet



315- Non MMT Fuel
316- MMT Fuel


#304 EXPLORER
105,367 MILES
MMT FUEL
BRICK TWO
#307 EXPLORER
105,384 MILES
CLEAR FUEL
BRICK TWO
#304 EXPLORER
105,367 MILES
MMT FUEL
BRICK ONE
#307 EXPLORER
105,384 MILES
CLEAR FUEL
BRICK ONE